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Indian Standard

METHODS FOR MEASUREMENT OF AIR POLLUTION

PART XV MASS CONCENTRATION OF PARTICULATE MATTER IN THE ATMOSPHERE

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NEW DELHI 110002

Gr 3 January 1975

Indian Standard

METHODS FOR MEASUREMENT OF AIR POLLUTION

PART XV MASS CONCENTRATION OF PARTICULATE MATTER IN THE ATMOSPHERE

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Indian Standard

METHODS FOR MEASUREMENT OF AIR POLLUTION

PART XV MASS CONCENTRATION OF PARTICULATE MATTER IN THE ATMOSPHERE

0. FOREWORD

0.1 This Indian Standard (Part XV) was adopted by the Indian Standards Institution on 26 September 1974, after the draft finalized by the Air Pollution Sectional Committee had been approved by the Chemical Division Council.

0.2 This method is based on ASTM D 1899-68 'Method of test for mass concentration of particulate matter in the atmosphere', issued by the American Society for Testing and Materials, Philadelphia (USA).

0.3 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard (Part XV) covers method for the continuous recording of the mass concentration of particulate matter of known characteristics in the atmosphere in the size range of about 0·05 to 40 μm in diameter. Measurement is based on the light-scattering property of microscopic size solid or liquid particles dispersed in a gaseous medium. The method is specifically used in special situations, such as performance evaluation or atmospheric sampling in special cases. It is used for determination of acid mist or fly ash.

1.2 The maximum range of concentration measured by means of this method is equivalent to 1 to 100 000 μg of particulate matter per cubic metre of air. Calibration within closer concentration limits will permit full-scale readings covering more narrow concentration ranges, thereby increasing the sensitivity of the test over the specific range being measured. The full range of concentration measurable by this method is equivalent to an estimated atmospheric visibility range from 1 500 km to 15 m.

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*Rules for rounding off numerical values (*revised*).

1.3 The mass concentration is strictly proportional to the scattered light intensity only when the particle size, shape, etc, remain constant (*see* Note under **10.3**). For information relative to meteorological and topographical factors affecting the application of this method, reference shall be made to IS : 5182 (Part XIV)*.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 4167-1966† and the following, shall apply.

2.1.1 *Mass Concentration of Particulate Matter* — The mass of particulate matter per unit volume of gas expressed in micrograms per cubic metre.

3. OUTLINE OF THE METHOD

3.1 The mass concentration corresponding to a reading of the instrument depends on the type of particulate matter in the atmosphere. The atmosphere under test is screened to remove particles greater than approximately 40 µm in diameter. The screened air passes through a dark-field illuminated smoke chamber and then through a weighed filter to collect the particulate matter, and finally is expelled. The dark-field illumination is arranged so that only small-angle, forward-scattered light from the aerosol strikes a photomultiplier tube, and the current generated is amplified, metered, and recorded. The particulate matter collected during the test period is weighed to obtain the average mass concentration corresponding to the average recorded reading. The calibration curve of the instrument is then used to obtain the variations of mass concentration of this particulate matter during the sampling period. The readings of different instruments are compared by standardization with a standard aerosol.

4. APPARATUS

4.1 Amplifier — A logarithmic amplifier, internally regulated, and for operation with a potentiometer-type recorder. The amplifier may be incorporated in a housing with a suitable meter that has a 1-mA full scale, graduated in five divisions, each division being further subdivided into ten increments. A zero adjustment control shall be provided to regulate a compensating voltage for balancing stray light. A sensitivity adjustment mechanism shall be provided to alter the range and compensate for changes in electrical sensitivity and lamp output.

---

*Methods for measurement of air pollution: Part XIV Recommended practice for planning the sampling of the atmosphere (*under preparation*).

†Glossary of terms relating to air pollution.

4.2 Filter, Fibrous

4.3 Filter, Molecular

4.4 Flow Meters — dry gas meters of any type; one to measure air flow of 0·003 m^3/min and one to measure air flow of 0·019 to 0·025 m^3/min.

4.5 Pump — constant displacement vacuum pump capable of drawing 0·022 to 0·028 m^3 of air through the smoke chamber per minute.

4.6 Recorder — potentiometer-type recorder shunted with a resistor to provide the voltage drop appropriate to the recorder when used with the amplifier described in **4.1**.

4.7 Sampling Probe — a small funnel inserted in the free end of a suitable length of tubing, the other end of which shall be attached to the sample inlet of the smoke chamber. The length and material of the tubing shall be selected to avoid alteration of the aerosol. Materials such as some plastics, that may develop an electric charge, shall be avoided. Glass or stainlesss steel tubing is recommended. The funnel and tubing shall be of such size as to permit air intake by means of the pump described in **4.5** at the rate of 0·022 to 0·024 m^3/min. In addition, the funnel mouth shall be covered with a fine screen, or other means, to exclude airborne particles of greater diameter than approximately 40 µm.

4.8 Smoke Chamber — a cylindrical chamber embodying the features illustrated in Fig. 1. The chamber shall contain a smoke tube through which the sample can pass without entering the body of the chamber, a light source, two condenser lenses fitted with a diaphragm stop to produce dark-field illumination, a series of optical calibration filters of known light transmission characteristics, a photomultiplier tube mounted in a suitable housing, a cooling mechanism, and diaphragms to reduce stray light.

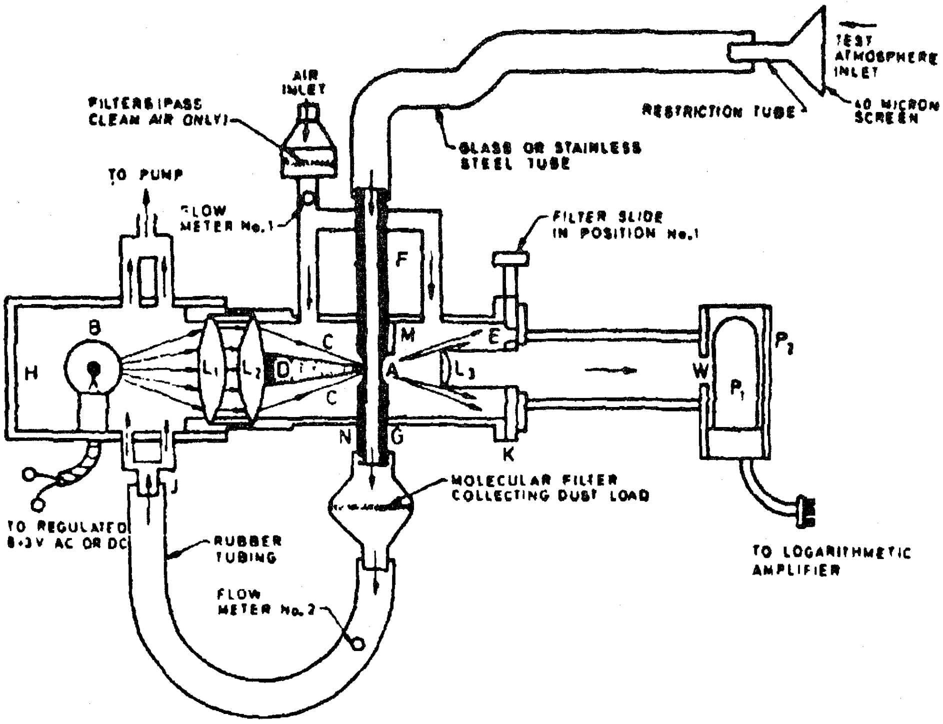
4.9 Voltage Regulator — any standard-type voltage regulator compatible with the light source in the smoke chamber described in **4.8**. The regulator shall be capable of stabilizing the voltage of the electric current supplied to the light source.

5. REAGENTS

5.1 Dichlorodifluoromethane

5.2 Di-2-ethylhexylphthalate

5.3 Latex — spherical particles of rubber, gutta-percha, chicle, balata or polystyrene.


AIR INLET
FILTERS (PASS CLEAN AIR ONLY)
TO PUMP
FLOW METER No.1
GLASS OR STAINLESS STEEL TUBE
RESTRICTION TUBE
TEST ATMOSPHERE INLET
40 MICRON SCREEN
FILTER SLIDE IN POSITION No.1
B
H
L₁
L₂
D
C
C
M
A
E
L₃
F
N
G
K
W
P₁
P₂
J
MOLECULAR FILTER COLLECTING DUST LOAD
TO REGULATED 8·3 V AC OR DC
RUBBER TUBING
FLOW METER No. 2
TO LOGARITHMETIC AMPLIFIER

A = Stray light-limiting aperture
B = Lamp
C = Cone of light
D = Diaphragm stop; produces conical shadow
E = Optical calibration filters
F = Test atmosphere inlet tube
G = Outlet tube
H = Sealed light source housing
J = Lamp-cooling air inlet
K = Rotatable flange
L_1 = Condenser lens
L_2 = Condenser lens
L_3 = Scattered-light collecting lens
M = Stray-light-limiting diaphragm
N = Sealed housing
P_1 = Photomultiplier tube
P_2 = Photomultiplier tube housing
W = Photomultiplier tube window; admits scattered light only

FIG. 1 OPTICAL SYSTEM CONSISTING OF SMOKE CHAMBER AND PHOTOMULTIPLIER TUBE

6. SAMPLING

6.1 Sampling shall be carried out as prescribed in IS : 5182 (Part XIV)*.

6.2 The sampling shall be discontinued when the atmosphere under test gives a reading off-scale when using the full range. This applies particularly to moderate or dense water fogs that would wet and damage the instrument.

7. CALIBRATION

7.1 Assemble the apparatus as shown in Fig. 1.

7.2 Install a weighed molecular filter in a holder at the outlet end of the smoke tube, and two fibrous filters in the clean air intake of the smoke chamber.

7.3 Turn on the power to the assembled apparatus, except that which operates the light source, and allow the apparatus to warm up in accordance with the characteristics of the specific apparatus being used.

7.4 Adjust the recorder (and meter if used) to zero position by means of the zero adjustment control. Close the tubing of the sampling probe, making certain that the clean air intake is open. With the instrument set to read scattered light, turn on the light source, note the stray light reading, and again adjust the recorder (and meter if used) to zero position.

7.5 By means of the sensitivity adjustment mechanism provided for the specific apparatus being used, adjust the sensitivity to give a full-scale reading with the optical calibration filter in position, appropriate to the range desired. Recheck the zero reading.

7.6 Insert the remaining optical calibration filters successively and plot a curve on 5-decade semi-log paper showing the relationship of recorder (and meter if used) readings to optical filter transmissions. The scattered light intensity from any aerosol is directly proportional to the filter transmission at a specific reading.

7.7 Check daily the calibration of the instrument, showing the relationship of recorder (and meter if used) reading to scattered light intensity.

8. STANDARDIZATION

8.1 Standardization of the instrument, providing a comparison of results obtained on different instruments, shall be made once a week (or month) as necessary, depending on the observed performance and reliability of the particular instrument The standardization may be made with

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*Methods for measurement of air pollution: Part XIV Recommended practice for planning the sampling of the atmosphere (*under preparation*).

dichlorodifluoromethane, di-2-ethylhexylphthalate, or latex. These or other stable materials may be used for standards as agreed upon.

8.2 Dichlorodifluoromethane gas, when passed through the instrument at standard temperature and pressure, provides the most readily available standard, but it gives only one reading near the lower end of the scale of the instrument. Adjust the instrument to read scattered light, disconnect the pump from the instrument, and close the tubing of the sampling probe. Connect the gas container to the clean air intake and blow gas through the instrument at 0·0028 m^3/min until a steady reading is obtained on the recorder (or meter). Note the reading on the calibration curve.

8.3 A standard aerosol will provide readings on any part of the scale depending on the particle size and concentration. Proceed as described in **9**.

NOTE — The standard aerosol generator should be controlled so that the mass concentration is constant, thus giving a constant reading on the recorder (or meter) during the standardization period.

9. PROCEDURE

9.1 Proceed in accordance with **7.2** to **7.5**, both inclusive.

9.2 Adjust the instrument to read scattered light and open the sampling probe. Introduce the atmosphere under test through the sampling probe at 0·0224 ± 0·0005 m^3/min and simultaneously enter clean air through the clean air intake at 0·002 8 ± 0·0002 m^3/min.

NOTE — The flow rates of aerosol and clean air should be checked frequently and maintained at the above values. The flow rate of aerosol should never exceed the flow rate of clean air by more than tenfold in order to prevent the entrance of particles into the body of the chamber.

9.3 Pass the atmosphere under test through the apparatus for a sufficient period of time to collect approximately 3 mg of particulate matter on the molecular filter.

NOTE — The pressure drop across the molecular and fibrous filters may become excessive due to clogging. The tendency to clog the filters varies with the concentration and type of particles collected. Under normal conditions the molecular filter should be replaced after 24 hours of operation, and the fibrous filters should be replaced after approximately 240 hours of operation. Failure to change filters at sufficiently frequent intervals may result in a change of flow rates or the escape of sample from the smoke tube, thus coating the wall and lenses of the smoke chamber with particulate matter which will increase the amount of stray light.

9.4 Discontinue introduction of the atmosphere under test, remove the molecular filter, insert a weighed new one, and resume introduction of atmosphere under test.

9.5 Weigh the filter containing the sample on an analytical balance under controlled humidity conditions. Note the exact mass of particulate matter collected and the sampling period of time.

NOTE — The sample to be weighed should be taken preferably during a period of time when the concentration is comparatively high and constant in order to shorten the sampling time and reduce the variations in the recorded readings. The procedure should be repeated at such intervals as appear necessary from the nature and behaviour of the atmosphere under test and the accuracy desired. All particulate matter under test should be collected on a molecular filter for observation of its characteristics. The observations may readily be made under a microscope by making the filter transparent by impregnation with immersion oil according to usual practice.

9.6 If the recorded readings are approximately constant during the sampling period, then any of the readings may be assumed to be representative of the average reading for the whole sampling interval. The corresponding filter transmission value may be read from calibration curve which relates instrument readings to transmission values. If the recorded readings vary significantly, it is necessary to determine the average filter transmission value from a plot on linear coordinate paper of the filter transmission values corresponding to the recorded readings. This may be done by either of two ways, by a weighing technique or by the use of planimeter. In the weighing technique the area under the plotted curve is cut out and weighed. This weight is then compared with a reference standard consisting of known weight of a rectangle of a similar paper having the same time base and a given transmission value.

10. CALCULATION

10.1 Calculate the average mass concentration during the sampling period, as follows:

$$A = (C \times 1\,000)/FT$$

where

A = average mass in µg of particulate matter per cubic metre of air during the sampling period,

C = particulate matter in mg collected on the molecular filter,

F = flow rate through the sampling probe in m^3/min, and

T = total sampling time in minutes.

10.2 Calculate the average optical filter transmission during the sampling period, as follows:

$$\bar{I} = (M_1/M_2)\,I_s$$

where

$\bar{I}$ = average optical filter transmission in percent for a given sampling interval,

M_1 = mass of paper cut out of plotted curve in g,

M_2 = mass of reference paper standard in g, and

I_2 = transmission value for reference standard.

NOTE — The method involving the use of the planimeter will give values for the areas under both the plotted and reference curves. These areas take the place of the masses in the above equation to determine an average filter transmission.

10.3 Calculate the mass concentration of the atmosphere under test at any specific moment of time, as follows:

$$a = \bar{A}\, i / \bar{I}$$

where

a = mass concentration at any time in $\mu g/m^3$,

$\bar{A}$ = average mass concentration obtained in **10.1**,

i = optical filter transmission (from calibration curve) corresponding to recorded reading at that time, and

$\bar{I}$ = average optical filter transmission obtained in **10.2**.

NOTE — This calculation is valid only if the particulate matter in the atmosphere at the selected moment of time is the same as it was during the sampling period, for the reason that the mass concentration is strictly proportional to the scattered light intensity only when the particle size, distribution, shape, refractive index, and colour of the particulate matter remain constant.

11. REPORT

11.1 The report shall include the following:

a) Mass concentration of the particulate matter;

b) Percentage ofoptical filter transmission;

c) Hour and minute recorded at the beginning and the end of the sampling time (**10.1** and **10.2**), or the hour and minute data were recorded for the mass concentration determination (**10.3**); and

d) Date of record.

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Indian Standard

METHODS FOR MEASUREMENT OF AIR POLLUTION

PART 21 NON METHANE HYDROCARBONS IN AIR BY GAS CHROMATOGRAPHY

ICS 13.040.20; 71.040.50

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BUREAU OF INDIAN STANDARDS
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June 2001 **Price Group 3**

Air Environment Protection Sectional Committee, CHD 032

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Air Environment Protection Sectional Committee had been approved by the Chemical Division Council.

The measurement of non methane hydrocarbons provides data for assessing atmospheric hydrocarbon pollution from motor vehicles, filling stations, petroleum refineries and a variety of industrial processes employing solvents. The term non methane hydrocarbons is chosen for two reasons. Firstly, methane concentration in atmospheric air is so high that no pre-concentration is required for its measurement, unlike for the other hydrocarbons. Secondly, the role of methane in atmospheric photochemical reactions is negligible in comparison with the other hydrocarbons put together. The method given in this standard is applicable for determining the hydrocarbon concentrations in working environment, urban environment as well as for measuring in clean air atmospheres. The data obtained by this method will be useful for determining the air quality as well as to determine the contribution of different sources to atmospheric hydrocarbon levels. This test method is one among the different parts being published under IS 5182 series of standards.

The composition of the committee responsible for preparation of this standard is given in Annex A.

In reporting the result of a test or analysis made in accordance with this standard if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

METHODS FOR MEASUREMENT OF AIR POLLUTION

PART 21 NON METHANE HYDROCARBONS IN AIR BY GAS CHROMATOGRAPHY

1 SCOPE

1.1 This standard prescribes the method of measurement of non methane hydrocarbons in the atmosphere. The lower limit of detection is 0.1 parts per billion (1 part in 10^{10} parts of air) by volume by pre-concentration method.

1.2 Two separate columns are recommended for the separation of hydrocarbons, one for C_2-C_5 and the second for C_6 and above hydrocarbon. Approximately 25 min are recorded for each analysis. The separation of ethane-ethylene on *n*-octane poracil C column needs sub-ambient temperature programming. Programmed temperature is needed for the separation of complex mixture of hydrocarbons.

2 REFERENCE

The following Indian Standard contains provisions which through reference in this text, constitutes provision of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below.

IS No.	*Title*
4167 : 1980	Glossary of terms relating to air pollution (*first revision*)

3 TERMINOLOGY

For the purpose of this standard, definition given in IS 4167 shall apply.

4 OUTLINE OF THE METHOD

4.1 This method is applicable for routine analysis of hydrocarbons in air samples collected in stainless steel canisters, glass bulbs with teflon stop cock or inflatable teflon bags fitted with on/off valves. Since some of the hydrocarbons are modified in atmospheric air by sunlight and by reaction with oxides of nitrogen, air sampling for hydrocarbons is recommended to be done between 6 and 9 AM. Direct injection of 1 to 2 ml of the sample air into a gas chromatograph equipped with molecular sieve 13 X, 80-100 mesh filled in 1 830 mm × 3 mm inner diameter (I. D.) stainless steel column kept at 100°C in a helium or nitrogen gas flow, will give peak corresponding to methane concentration in sampled air. The retention time for methane at the above operating conditions with helium flow rate of 80 ml/min is 1.08 min.

4.2 Pre-Concentration

Atmospheric non methane hydrocarbons are to be pre-concentrated to determine their concentrations at below the detection limit of 0.01 ppm by direct injection using a flame ionization detector (FID). The recommended method for pre-concentration of gas phase hydrocarbons is by cryogenic condensation using liquid argon [Boiling point (B.P.) : 186°C], liquid oxygen (B. P. : 183°C) or liquid nitrogen (B. P. : 196°C). Liquid nitrogen is most used cryogenic fluid in laboratories and hence the current method is based on the use of this cryogen. However, if a laboratory has an easy supply of liquid argon or liquid oxygen, it should be used in place of liquid nitrogen. The use of liquid argon prevents condensation of oxygen and nitrogen during pre-concentration. Use of liquid oxygen requires extreme caution as the reactions of most organic compounds with liquid oxygen are highly exothermic.

4.3 *n*-octane poracil C, 80-100 mesh, filled into 3 050 mm × 1 mm inner diameter (I.D.) stainless steel column is recommended for separation of C_2-C_5 hydrocarbons. A column temperature of 27°C and a helium flow rate of 40 ml/min are recommended. If helium is not available nitrogen could be also used. Flame ionization detector is used for detection. Zero air or oxygen is used for supporting the flame in FID.

4.4 Since ethane and ethylene can not be separated at 27°C, alternate column recommended for separation of C_2-C_4 hydrocarbons is porapak Q , 80-100 mesh filled in a stainless steel column of 1 830 mm × 3 mm inner diameter (I. D.) at 50°C in a nitrogen flow of 30 ml/min.

4.5 Capillary Column

Of fused silica, porous, open tubular column of 50 m × 0.32 mm inner diameter or other equivalent column for hydrocarbon analysis.

5 ERRORS IN SAMPLING AND MEASUREMENT

5.1 Generally, for a homogeneous urban air mass, hydrocarbon contaminants would be expected to fall within the ranges given in Table 1. Stainless steel canisters are ideal for storage of gases, but have the limitation of low volume, large weight. Glass bulbs with teflon stop cocks are preferred next, but have the risk of breaking. Teflon bags can be used to collect samples upto 5 litres, but are not available indigenously. The loss in storage in teflon bags could be 10 percent and higher due to 'breathing' by the bags. The problem of contamination due to needle valves should be checked while using stainless steel canisters.

Table 1 Ranges of Hydrocarbon Concentrations Expected in Urban Air

(*Clause* 5.1)

Compound	Range (ppm)
Methane	1.6 - 15
Ethane	0.005 - 0.5
Ethylene	0.004 - 0.3
Propane	0.003 - 0.3
Propene	0.001 - 0.1
Acetylene	0.001 - 0.2
iso-butane	0.001 - 0.1
n-butane	0.004 - 0.4
1-butene	0 - 0.02
2-methyl propene	0 - 0.02
2,2, dimethyl propane	0 - 0.01
Trans-2 butene	0 - 0.01
cis-2-butene	0 - 0.01
iso-pentane	0.002 - 0.2
n-pentane	0.002 - 0.2

5.2 As a general rule, if methane, ethane or propane concentrations are high relative to other identified hydrocarbons, look for local source emission of natural gas. If acetylene and the butenes are high, look for automobile exhaust source. If *n*-butane and *iso*-butane are high, look for liquid petroleum gas filling leakage source and if *n*-pentane and *iso*-pentane are high, look for a source of gasoline evaporation.

6 APPARATUS

6.1 Gas Chromatograph (GC)

A gas chromatograph modified to facilitate pre-concentration of non methane hydrocarbons is shown in Fig. 1.

6.1.1 The gas chromatograph column inlet instead of connecting to injection port is connected to port 2 of a 6-port valve. A capillary stainless steel tube is connected from injection port of GC to port 1 of the 6-port valve.

6.1.2 A U-column of 30 cm length, 3 mm outer diameter, partially filled with glass beads 60-80 mesh is connected to ports 3 and 4 of the valve. During pre-concentration, this column is dipped to 1 cm into a liquid nitrogen bath in a Dewar flask.

6.1.3 Sampling canister or glass bulb or teflon bag is connected by means of a thin stainless steel tube to port 5 of the gas sampling valve via a needle valve. Another stainless steel canister of 1 litre capacity fitted with a vacuum gauge and a needle valve is connected to port 6 of the 6-port valve. This canister is partially evacuated so that when the needle valves are opened after the U-column is cooled by liquid nitrogen, sample air flows through the U-column and the hydrocarbons are condensed.

6.1.4 A water bath (60-70°C) replaces the Dewar flask after the sample pre-concentration.

6.1.5 The U-column is connected to the two canisters in the pre-concentration mode and by turning the knob of the 6-port valve, gets connected to the injection port and the analytical column.

6.1.6 *Flame Ionization Detector and Electrometer Amplifier*

6.1.7 Integrator/Recorder gives the area/peak height of the chromatographic peaks.

6.2 For the purpose of calibration, sample canister is replaced by a stainless steel canister with a synthetic mixture of known composition.

7 PROCEDURE

7.1 Evacuated stainless steel canister of 500-ml capacity is filled with sample air. The sample may be dried with a short column of silica gel to prevent moisture getting into the canister. The sample is brought to the laboratory and connected to the 6-port valve as shown in Fig.1. At this stage, both the needle valves should be completely closed. The U-column should be dipped about 1 cm into liquid nitrogen bath.

> **Caution** : If the U-column is completely dipped into liquid nitrogen bath, large volume of oxygen and nitrogen condense in the U-column; on the other hand, if the cooling is not sufficient, condensation of non methane hydrocarbons does not take place.

The pressure of the partially evacuated canister should be adjusted to 400 mm of mercury. By keeping the needle valve on the sample canister closed,open the needle valve on the partially evacuated canister. The pressure in the canister does not change if the gas line connections are leak tight. After cooling the U-column for 3-5 min, open the needle valve on the sample canister gently so that sample air flows through the U-column at a slow rate. Continue pre-concentration till the pressure in the partially evacuated canister rises from 400 mm to 480 mm as read on the vacuum gauge attached to the canister. Close the two needle valves. Connect a vacuum pump to the partially evacuated canister and reduce the pressure in this canister to 160 mm. Open the upper needle valve for 3 to 5 s, keeping the needle valve on the sample canister closed tight. By this, the pressure in the U-column is reduced to 160 mm and any nitrogen or oxygen which may have condensed re-evaporates. Close both the needle valves, heat the U-column with water bath and turn the knob

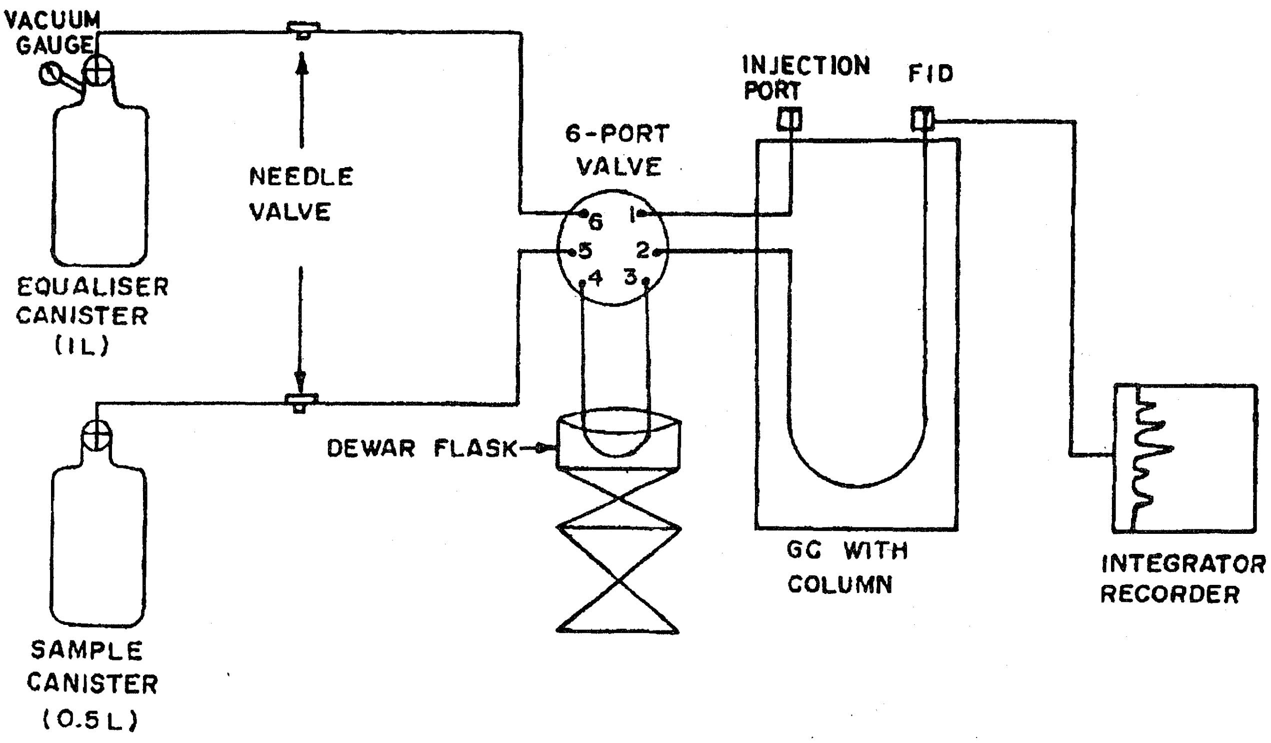


FIG. 1 PRE-CONCENTRATION SYSTEM AND GAS CHROMATOGRAPH FOR NON METHANE HYDROCARBON MONITORING

of the 6-port valve so that the U-column is connected between the injection and the analytical column, simultaneously starting the stop-watch to record the retention times of peaks.

7.2 The chromatogram of pre-concentrated sample is shown in Fig. 2. The first peak is due to methane. Since the boiling point of methane is -165°C, it does not condense at the pre-concentration temperature (which is kept at about -110°C). However, methane present in the free volume of the U-column will be recorded in the chromatogram. Ethane-ethylene will emerge as a single peak, followed by acetylene, propane, propylene, butene isomers, *iso*-butane, *n*-butane, *iso*-pentane, *n*-pentane and *neo*-pentane. The retention times of higher hydrocarbons are much larger at 27°C on *n*-octane poracil C column and hence a separate column is recommended for the analysis of C_6 and above hydrocarbons.

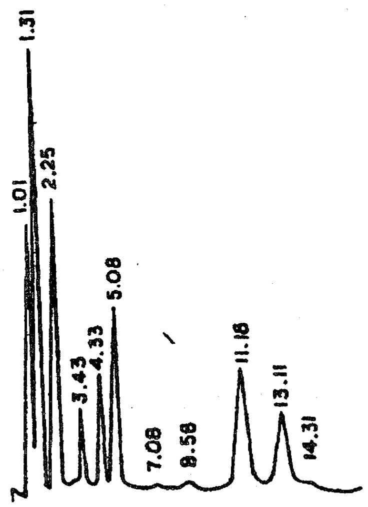
7.3 Quantification

7.3.1 To determine the concentrations, it is required to determine the volume of pre-concentrated sample. Let *V* be the volume in litres, of partially evacuated canister. If the pressure of this canister rises from 400 mm to 480 mm during pre-concentration, the volume of air sampled is

$$\frac{(480 - 400)}{760} \times V = \frac{80}{760} \times V \text{ litres}$$

If the temperature of this canister is t°C, then the corrected gas volume at standard temperature and pressure is

$$\frac{80}{760} \times \frac{273}{(273 + t)} V$$



Column : *n*-octane poracil C
80-100 mesh
1.8 m × 1 mm ID × 3 mm OD
Temp : 27°C (*iso*-Thermal)
Carrier : Helium
Flow Rate : 40 ml/min
Detector : FID
Sample : 140 ml of Air pre-concentrated

FIG. 2 CHROMOTOGRAM OF PRE-CONCENTRATED AIR SAMPLE ANALYSED FOR C_2-C_5 HYDROCARBONS

7.3.2 Similar pre-concentration step is done replacing the sample canister with a canister containing standard gas mixture. If the same volume of gas mixture is used for pre-concentration, then the concentration of each hydrocarbon component is simply given by

$$C = \frac{A_{\text{sample}}}{A_{\text{standard}}}$$

where C is the concentration in ppm of the component in the standard gas mixture and A_{sample}, A_{standard} are the respective areas in the chromatogram for the sample and standard hydrocarbons.

7.4 Sample collection, pre-concentration and analysis as described above may be repeated with the analytical column replaced by OV-101, 10 percent on Chromosorb WAW 80-100 mesh, stainless steel column of 3 000 mm × 1mm inner diameter for the determination of C_6 and above hydrocarbons. Following operating conditions are maintained:

Column temperature : Initial temperature : 60°C;
Initial time : 5 min;
Rate : 5°C/min;
Final temperature : 100°C

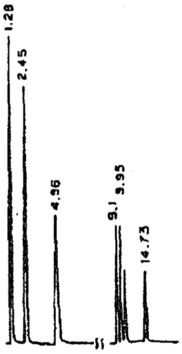
Carrier gas : Helium/nitrogen at 40 ml/min
Flame ionization detector

7.4.1 Typical chromatogram for pre-concentrated sample is shown in Fig. 3.

7.4.2 *Quantification*

The volume of air sampled is determined as in 7.3. The amount of each solvent is determined by comparing the chromatogram with standards injected.

Concentrations of solvents are expressed in either mg/l or ppm.



Column : 10% OV-101 on Chromosorb WAW, 80-100 mesh
Initial Temp : 60°C
Initial Time : 5 min
Rate : 5°C/min
Final Temp : 100°C
Carrier Gas : Helium
Flow Rate : 40 ml/min
Detector : FID
Sample : 0.5 λ of CS
(Containing 0.25×10^{-3} λ of each compound)

FIG. 3 CHROMOTOGRAM OF PRE-CONCENTRATED HYDROCARBONS ON OV-101 COLUMN

ANNEX A

(*Foreword*)

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